

SAFETY IN MATERIAL STORAGE AND HANDLING OF ALUMINIUM POWDER

ABSTRACT

Aluminium Powder in Flake form is one of an important ingredient in the manufacturing of Mining Explosives, Aerated Autoclaved Cement Concrete Blocks, Aluminium Phosphide, Firecrackers, Pigments and Pastes. Besides, Atomized Aluminium Powder in Thermit Welding, Mining Explosives, Refractories and Chemical Formulations. Aluminium Powder can be shipped, stored and used with good Housekeeping and by following basic rules of safety. Under certain condition, aluminium powder can ignite or explode, however, if the safety recommendations are followed, the hazard will be substantially reduced.

PRODUCT DEFINITIONS :

Aluminium Powder: Aluminium powder can be divided into three broad classifications: Atomized, Flake and Granules. The length or width of Flake particles pigment may be several hundred times its thickness. The length, width, and thickness of an Atomized particle are all of approximately the same order, the length dimension probably not exceeding two or three times the thickness dimension. Granules are particles larger than 200 mesh. The difference in form is important as it greatly influences the characteristic that allows aluminium powder to burn or explode.

BACKGROUND:

Why powder burns:

Chemically, aluminium has an enormous affinity for oxygen. This results in a thin film of aluminium oxide being produced almost instantaneously on the surface of the aluminium when exposed to the atmosphere. The aluminium oxide film is inert and it protects the underlying metal from further attack.

When an aluminium powder particle is heated to a certain temperature (known as “**ignition point**”), the mass of the particle is so small that the entire particle may oxidize almost instantly. Thus a pile of such particles will “**burn**”. Since flake particles are much smaller in mass and have much greater surface area per unit mass than atomized or granular particles, they will ignite more readily and burn faster than the coarser types of powder.

Why powder explodes:

Fine particles of aluminium powder, like some organic powders such as flour, starch and coal dust, are easily dispersed in air where their light mass allows them to remain suspended or “**float**” in the air. Like particles in a pile, they will burn when the ignition temperature is reached; but when dispersed in the air (mixed with oxygen) in a certain proportion, the burning extends from one particle to other with such rapidity (rate of pressure rise in excess of 20,000 psi/sec) that a violent explosion results. Laboratory tests by the U.S. Bureau of Mines and others have established the proportion required for an explosion. Aluminium dust will ignite with as little as 9% oxygen present, the balance being nitrogen; or 10% oxygen with the balance helium; or 3% oxygen with remainder carbon dioxide. Very small amount of energy is required to ignite certain mixtures of aluminium powder and air. In some cases, energy as low as 25 milli joules may cause ignition.

COMMON SOURCES OF IGNITION AND CAUSES OF DUST EXPLOSION:

The discharge of static electricity will produce an electric spark that raises the powder particle in its vicinity above the ignition point resulting in an explosion. Electric switches, broken light bulbs, electric motor commutators, and loose electric power connection-even a metal-to-metal impact- anything producing a spark can set off an explosion. Even continued metal-to-metal rubbing (as in dry sleeve bearing) can generate enough heat to set off an explosion.

GENERAL:

1. Storage should preferably be in rooms of the high resistive, noncombustible or limited combustible construction.
2. Aluminium powder should not be stored in areas containing flammable liquids or other combustible materials because of differences in firefighting methods.
3. Stack containers properly with ample aisle space. Keep stack heights to a minimum.
4. All electrical wiring should be enclosed in conduit .All lights should be with adequate, protective enclosures.
5. Leaks in steam lines, water lines, radiator or roofs should be promptly repaired to avoid exposure of the products to water.
6. Exercise good housekeeping. Guard against the accumulation of dust on floors, walls, and other construction. Keep all rubbish, such as oily rags, papers and other combustibles, out of the areas.
7. Post "No Smoking" signs and enforce the rule. Do not use open lights, blow torches, welding torches, or permit open fire in storage and handling areas.
8. Avoid friction sparks. Do not permit careless metal-to-metal contact or metal against concrete. In handling aluminium powder, use non sparking metal scoops or shovels; plastic and ferrous metal should not be used.
9. Keep containers far enough away from steams pipes or radiators to prevent heating.
10. Keep all containers sealed except when open for removal of material.

ALUMINIUM POWDER STORAGE:

1. Aluminium powder stored in warehouses should be stored in original shipping containers and kept tightly sealed.
2. Avoid contacting the aluminium powder with water since this will eventually result in the reaction of aluminium with water causing heat and formation of hydrogen gas and possible pressure build up.
3. Keep all containers carefully sealed except when opened for the removal of material.
4. When a container is opened in storage or on the job for removal of a portion of powder, replace cover and reseal to guard against air oxidation, other injurious gases, vapors or possible admission of other foreign material.

BASIC SAFETY PRINCIPLES TO BE FOLLOWED WHEN HANDLING ALUMINIUM POWDER

Rule 1 - Avoid any condition that will suspend or float powder particles in the air creating a dust cloud. The less dust suspended in the air, the better.

1. In transferring aluminium powder, dust clouds should be kept at an absolute minimum. Powder should be transferred from one container to another using a non-sparking, conductive metal scoop, with as little agitation as possible. Handling should be slow and deliberate to hold dusting to a minimum. Both containers should be bonded together and provided with a grounding strap.
2. In mixing aluminium powder with other dry ingredients, frictional heat should be avoided. The best type of mixer for a dry mixing operation is one that contains no moving parts, rather effects a tumbling action such as conical blender. Introduction of an inert atmosphere in the blender is highly recommended since dust clouds are generated. All equipment's are well-grounded.

Rule 2 - When possible, avoid actions that generate static electricity, create a spark or otherwise result in reaching the ignition energy or temperature.

1. Locate electric motors and as such electrical equipment as possible outside processing rooms. Only lighting and control circuits should be in operating rooms. All electrical equipment must meet the National Electrical Codes for hazardous installations. This includes flash lights, hazardous portable power tools and other devices.
2. Use only conductive material for handling or containing aluminium powders. Use only non-sparking conductive metal scoops for transferring powder. Note that both containers should be bonded together and provide with grounding straps.
3. **“NO SMOKING”**, except in controlled designated areas well away from operating and storage areas.
4. No open flames, fires or sparks should be allowed in operating and storage areas or dusty areas.
5. No matches, lighters, or any spark producing equipment can be carried by an employee.
6. During transfer, powder should not be poured or slid on non-conductive surface. Such actions build up static electricity.
7. Powder should always be handled gently and never allowed to fall from any distance. Remember, all movement of powder over powder tends to build up static charge.
8. Work clothing should be made of smooth, hard-finished, closely woven fire resistant / fire retardant fabrics which tend not to accumulate static electric charges. Trousers should have no cuffs where dust might accumulate.

Rule 3 - Where generation of static electricity may occur, utilize every means to minimize it and dissipate it, such as bonding and grounding, to avoid a spark discharge.

1. Bonding and grounding of machinery (to remove static electricity produced in powder operation) are vital for safety. All moveable equipment, such as drums, containers and scoops must be bonded and grounded during powder transfer by use of clips and flexible ground leads.

Rule 4 - Take steps to limit size of a fire or explosion and to hold any resulting damage to the very minimum.

1. Keep all containers sealed. Store these unopened in a separate area. If stored with such chemicals as sulphur, nitrates or other strong oxidizing agents, a fire would present a serious problem.
2. When a drum of aluminium powder is opened for loading or inspection, it should be closed and resealed as quickly as possible. This will not only assure greater safety against fire from external cause but prevent possible entrance of moisture from the air. In past instances, sealed drums of flake powder have withstood an explosion and subsequent fire without ignition of the contents of the drum.
3. Consider the use of an inert gas which can be valuable in minimizing the hazard of handling powder in air.
4. All contents in work areas should be closed and sealed. Only those in actual use should be open at any time.

FIRE FIGHTING METHODS

Aluminium Powder

Since it is almost impossible to extinguish a massive fire in dry light metal powder, the fire problem resolves itself into the control of fires in the incipient stage. Aluminium powder in bulk is ignitable only with difficulty. However, once suspended in a dust-air cloud, it is readily ignited and very explosive.

The use of fine dry sand, preferably that screened through a 20 mesh sieve, or use of an acceptable proprietary dry extinguishing material, is at present the best known method of fighting incipient fires of aluminium powder. Water streams or liquid sprays of various kinds that vaporize quickly are highly dangerous since the dust is

thrown into the air and the ignited particles instantly cause a violent explosion of the dust. For the same reason, any mechanical agitation or disturbance of the burning powder or that adjacent there to must be avoided. Ample supply of dry fine-screened sand or other approved powder should be kept in covered bins or covered receptacles, each containing about a cubic yard. These receptacles should be placed a sufficient number of suitable points at or in each building, convenient to reach quickly. These receptacles should be covered and arranged so that the sand can be quickly scooped up by a bucket or shovel. These implements shall be made of aluminium or other nonferrous materials.

In fighting an aluminium powder fire, avoid stirring it. All electric power in the area should be first shut off, then if the aluminium powder is burning quietly in a place where it can be safely isolated, the sand should be carefully ringed around but not dropped on the burning powder, great care being taken to avoid fanning the dust into the air. The powder, when burning quietly, forms a crust which excludes oxygen and gradually extinguishes itself. As soon as the isolation of the fire has been accomplished, the room should be closed, the windows shut, the bottoms of the doors sealed with sand, and the fire allowed to burn itself out.

Water and other extinguishers shall not be used. Since water reacts with hot aluminium powder to form hydrogen. The force of a water hose stream could suspend the aluminium powder to form a dust cloud. All liquid, carbon dioxide or foam type extinguishers shall be rigidly excluded from the plant areas storing or processing dry powder to prevent their being used by excited and in-experienced persons during an emergency. All liquid, halogenated, carbon dioxide or foam type extinguishers should be rigidly excluded from the plant areas storing or processing dry powders to prevent their being used by excited and inexperienced persons during an emergency. All fans and machinery, including dust collection system, should be shut down. Drafts should be avoided wherever possible.

Metal dust fires on reasonable flat surface may be controlled by placing ring dam of dry sand or class D dry extinguishing material around the burning area. This should be done with great care to avoid any disturbance of the powder which could create a dust cloud. Even a minor dust cloud can explode violently.

Long handled shovels or scoops of non-sparking material should be provided for the application of dry extinguishing agents.

A properly ringed fire will develop a hard crust of metal oxide which will ultimately exclude enough oxygen to cause self-extinguishment. It is customary practice, after dispensing the extinguishing material, to leave the area, closing all doors leading to the area and sealing them with sand. The area should not be re-entered until combustion has stopped and the material has cooled.

FIRE FIGHTING ORGANIZATION:

The operating crew should be consists of men trained to combat the fires of the type encountered in these processes and only these men should be permitted near the area involved by fire. It is preferable that one individual in this crew be responsible for directing firefighting operations until more senior personnel arrive on the scene. Local town or city fire men, who might be called to the plant in case of fire, shall be thoroughly instructed in the dangers of using jet of carbon dioxide, water, carbon tetrachloride or other liquid in an aluminium powder fire. They should receive positive orders from their superior, by prior arrangement with the respective officials, forbidding such is in combating any fire in the aluminium storage area.

Professional or volunteer fire fighters from outside the plant cannot be expected to be trained for the specific fire and life hazards associated with aluminium powder and paste fires. They should be directed by the plant's firefighting officer in the interest of their own safety.

REFERENCES

1. M. Jacobson, Austin R. Cooper, John Nagy, Explosibility of Metal Powders, in U.S. Bureau of Mines Report of Investigation No.6516.
2. National Fire Protection Association, No.65-1973,Fire Extinguishers, Processing and Finishing of Aluminium (ANSI Z12.19)
3. National Fire Protection Association, No.651, Chapter 10, Dust Explosion Prevention-Aluminium powder
4. National Fire Protection Association, No. 77, Recommended Practice on Static Electricity.
5. National Fire Protection Association, No.10-1972 (ANSI z 112.1-1972).Portable Fire Extinguishers

Sources for Obtaining These Documents:

1. U.S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, PA 15213
2. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269
3. American National Standards Institute, 1430 Broadway, New York, NY 10018